Attachment A

CALCULATION OF CONCENTRATION SIGNIFICANCE THRESHOLDS FOR INCREMENTAL INDIVIDUAL CANCER RISK

A.1 Introduction

For this study, the significance threshold for cancer risk is defined for all pollutants as a lifetime (i.e., 70 year) incremental cancer risk greater than 1×10^{-6}. In other words, if exposure to the substance released in the quantities estimated from a high density of producing Pinedale Anticline Project wells will result in one additional cancer case per million people exposed, the effect is considered to be significant. This incremental cancer risk is translated to pollutant concentration thresholds for direct comparison with model output.

A.2 Calculation

Risk values (RV), such as the value given above (i.e., 1×10^{-6}), can be calculated on a pollutant by pollutant basis as the product of an annual pollutant concentration (C), an EPA-designated pollutant-specific unit risk factor (URF), and an adjustment factor (AF). Therefore, conversion of the risk value to threshold pollutant concentrations is accomplished using Equation 1 below. An explanation of each of the parameters used in the calculation is provided below.

Equation 1: $$C_{threshold} = (RV_{threshold}/AF)/URF$$

$C_{threshold}$ ($\mu g/m^3$):

In the above equation, $C_{threshold}$ represents the threshold pollutant concentration that is equivalent to the threshold cancer risk value ($R_{threshold}$). (Note that $C_{threshold}$ is a pollutant-specific value.)

URF $(\mu g/m^3)^{-1}$:

The EPA unit risk factors (URF) are defined by the Environmental Protection Agency as the "upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of...1 $\mu g/m^3$ in air" (taken from the EPA Integrated Risk Information System website - http://www.epa.gov/ngispgm3/iris/glossary.htm). The unit risk factors for benzene and formaldehyde are shown in Table A.1.

TABLE A.1
EPA UNIT RISK FACTORS

Hazardous Air Pollutant	Unit Risk Factor $(\mu g/m^3)^{-1}$
Benzene	8.3×10^{-6}
Formaldehyde	1.3×10^{-5}

AF:

The adjustment factors are calculated for two scenarios: 1) maximum exposure scenario; and 2) most likely exposure scenario. The parameters used in the calculations are shown in Table A.2.

TABLE A.2
ADJUSTMENT FACTOR PARAMETERS

	Maximum Exposure Scenario	Most Likely Exposure Scenario
Percentage of time exposed ($TE_{\%}$) at exposure level ($EL_{\%}$)	100% at exposure level of 100%	64% at exposure level of 100%; 36% at exposure level of 25%
Basis of calculation (BC) ¥	70 years	70 years
Duration (D)	30 years	9 years*

¥ The risk estimate is based on the increased cancer risk over a 70-year lifetime.
* Exposure Factors Handbook, Environmental Protection Agency, 1990/8-89-043, March 1985, and subsequent updates.

The basic formula for the calculation of the adjustment factors (AF) is shown as Equation 2:

Equation 2: $$AF = (D/BC) * \sum TE_{\%} * EL_{\%}$$

The adjustment factor for the maximum exposure scenario (AF_{MAX})is:

$$AF_{MAX} = (30/70) * 100\% * 100\% = 0.43$$

The adjustment factor for the most likely exposure scenario (AF_{MLE})is:

$$AF_{MLE} = (9/70) * [64\% * 100\% + 36\% * 25\%] = 0.094$$

A.3 Results

Using Equation 1 to convert the 1×10^{-6} risk factor to a corresponding pollutant concentration results in the threshold concentrations presented in Table A.3.

TABLE A.3
CALCULATED THRESHOLD CONCENTRATIONS

	Benzene		Formaldehyde	
	Maximum Exposure	Most Likely Exposure	Maximum Exposure	Most Likely Exposure
URF	8.3×10^{-6}	8.3×10^{-6}	1.3×10^{-5}	1.3×10^{-5}
AF	0.43	0.094	0.43	0.094
$R_{threshold}$	1×10^{-6}	1×10^{-6}	1×10^{-6}	1×10^{-6}
$C_{threshold}$	0.28	1.28	0.18	0.82